EXPORTING FLORIDA GRAPEFRUIT TO JAPAN-- AN EVALUATION OF NEW SHIPPING CONTAINERS AND DECAY-CONTROL TREATMENTS

Talk by Philip W. Hale, Agricultural Economist, and
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at the
1973 Annual Citrus Packinghouse Day
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Lake Alfred, Florida, September 5, 1973

It is a pleasure to participate in your Annual Citrus Packinghouse Day program. Basically, we all have the same objective in mind--to deliver fresh Florida grapefruit to domestic and overseas markets in the best possible condition. We are pleased to report that the information gained from two commercial shipping tests will be helpful in meeting this objective.

The results of evaluating new types of 4/5-bushel shipping containers and new decay-control treatments indicate that when better packaging techniques are used and improved fungicidal treatments are adopted, the appearance and condition of grapefruit on arrival at overseas markets will be enhanced.

This study is part of a broader research program by the U.S. Department of Agriculture and the citrus industry to find ways of reducing the cost of distributing and improving the arrival condition of agricultural food products at overseas markets. Trade names used in this report are solely to provide information. Mention of a trade name does not constitute an endorsement or warranty of the product by the U.S. Department of Agriculture.

This study evaluated 11 types of shipping containers (Table 1, identification letters A, B, C, D, E, I, J, K, L, M, and N) and 9 different decay-control treatments (Table 2) for exporting Florida Marsh Seedless grapefruit from Orlando, Florida, to Tokyo, Japan.

In addition to the 11 types of shipping containers, 2 other variations in containers were tested to compare the cooling rates of all containers with standard ventilated cartons (Table 1,A). Experimental airflow ventilation slots were cut into the bottom and top flaps of 2 of the carton types (Table 1, F and O). Also, 2 palletized units of cartons (Table 1, G and H) were included in the tests to observe handling methods and the effects of cooling rates of standard-ventilated and airflow-ventilated cartons when unitized on pallets. Thus, a total of 15 shipping containers were evaluated when 2 break-bulk shipments were conducted during March and April 1973, along with regular commercial shipments. The transit time for the 2 shipments from packinghouse (Florida) to destination (Japan) was 44 and 45 days, respectively.

TABLE 1.--Descriptions, specifications, and identification letters for the 15 types of shipping containers, 2 test shipments from Florida to Tokyo, Japan, 1973.

Type of carton 1/	Identification letter	Paperboard weight: Cover	Paperboard weight: Body	Bursting strength: Cover	Bursting strength: Body	Ventilation slots: End panel	Ventilation slots: Side panel
		(lb/1,000 ft^2)					
Standard: Fiberboard, full telescope	A	42-33-42	90-33-90	200	350	0	2
Experimental: Fiberboard							
Full telescope	B	42-33-42	69-33-69-33-69	200	500	0	2
Bliss-style 2/	C	42-33-62	42-33-62	250	250	2	3
Full telescope 3/	D	42-33-42	62-33-62	200	275	0	2
Full telescope 2/	E	42-33-62	62-33-62	250	275	0	2
Full telescope, airflow 4/	F	42-33-42	90-33-90	200	350	0	0
Full telescope, unitized	G	42-33-42	90-33-90	200	350	0	2
Full telescope, airflow, unitized 4/	H	42-33-42	90-33-90	200	350	0	0
Full telescope 4/ 5/	I	42-33-42	90-33-90	200	350	0	2
Full telescope 6/	J	42-33-42	69-33-69	200	275	0	2
Full telescope 4/ 7/	K	42-33-42	90-33-90	200	350	0	2
Full telescope 8/	L	42-33-42	90-33-90	200	350	0	2
Full telescope 9/	M	42-33-42	90-33-90	200	350	0	2
Full telescope	N	42-33-42	73-pm-73 10/	200	--	0	2
Full telescope, airflow	O	42-33-42	73-pm-73 10/	200	--	0	0

1/ Waterproof adhesives were used throughout in bodies of all shipping containers.
2/ Body and cover fabricated from waterproof, nonwaxed corrugated board. The 33-lb medium and the 62-lb liner of body and cover were wet strength.
3/ Body fabricated from waterproof, nonwaxed corrugated board. The 33-lb medium and the 62-lb liner of the body were wet strength.
4/ The 33-lb medium of the body was wet strength.
5/ The inside liner of body treated with Mikelman X-300 coating.
6/ Body was wax dipped.
7/ Liners and medium of body were wax impregnated; both liner facings of body were curtain coated.
8/ Inserts of 275 lb paper board weight were placed inside the carton body against each end panel and extended 1-1/2 in. around each corner of the cartons.
9/ Liners and medium of body were wet strength.
10/ Medium of body fabricated from 5-mil polypropylene.
-- Data not available.

All shipping containers tested (Table 1) measured inside 17 X 10-5/8 X 9-5/8 in., and were regular slotted cartons, except treatment C, a Bliss-style carton. Treatment C had a modified, full-telescope cover with no joint on the top surface or the bottom surface of the carton. All flaps and joints (Treatment C) were on the ends of both body and top halves.

A regular commercial packinghouse was used to pack a minimum of 50 cartons of each type of container for each test shipment -- all with size 40 Marsh Seedless grapefruit. Two biphenyl pads were used in each carton between each layer of fruit. The test shipping containers were loaded in the refrigerated holds of the ships in a tight stack, eight and nine high. The cartons (G and H) on the 2 palletized units were held together with an experimental shrink-film sleeve. Six cartons of each type of container were specially identified and placed in the bottom layer of the carton stacks to evaluate the unitizing and break-bulk handling methods used. Individual net weights of fruit packed in the shipping containers and the average moisture content of the cartons were recorded at the shipping point.

For the fungicide test shipments, four standard commercial-type cartons for each of 9 decay-control treatments (Table 2) were tested, using size 40 or 48 grapefruit. Biphenyl pads were placed between each layer of grapefruit inside the shipping containers in all treatments. The decay-control treatments were applied at the Orlando laboratory, after which the containers were handled, held in storage, and loaded with commercial fruit. Thus, fruit in these treatments were also exposed to biphenyl vapors. In addition, comparable sample lots of the decay-control treatments that were not exposed to biphenyl vapors were held at the Orlando laboratory for a simulated transit period.

In test shipment No. 1, thermocouple leads were inserted into a grapefruit packed in each type of carton at the fourth layer to record pulp temperatures during transit. A hygrothermograph was placed adjacent to the test shipping containers to monitor temperatures and relative humidity.

The second shipment was unaccompanied, and relative humidity was not recorded; however, the transit temperatures in the refrigerated hold of the ship were monitored by 4 recording instruments.

TEST RESULTS

In test shipment No. 1, the pulp temperatures of the fruit packed in all test containers after they were loaded into the hold of the ship

TABLE 2.--Descriptions of the decay-control treatments used on grapefruit, two test shipments from Florida to Tokyo, Japan, 1973.

Treatment No.	Fungicide application	Wax application
1	Control treatment, wash only	#93 Flavorseal wax
2	Sodium orthophenylphenate, 2% Dowicide + 1% hexamine	#93 Flavorseal wax
3	2-Aminobutane, 1%	#93 Flavorseal wax
4	Thiabendazole, 1200 ppm	#93 Flavorseal wax
5	Treatment #2 followed by Treatment #4	#93 Flavorseal wax
6	Thiabendazole, 3000 ppm	#93 Flavorseal wax with 4000 ppm Thiabendazole
7	Sodium orthophenylphenate, 2% Dowicide + 1% hexamine	#93 Flavorseal wax with 4000 ppm Thiabendazole
8	Benomyl, 1000 ppm	#93 Flavorseal wax
9	Wash only	#93 Flavorseal wax with 4000 ppm Benomyl

ranged from 68° to 70°F. After 36 hr, the pulp temperatures of the fruit -- except fruit in the 2 palletized units (G and H) -- ranged from 50° to 52°F, a 18 to 20°F drop in temperature. There was no significant difference in the cooling rate of the grapefruit because of the container type or between containers with experimental airflow and standard ventilation. (The consistency here could be attributed to the efficient refrigeration system on this ship.) Temperatures were maintained (± 1°F) throughout the remainder of the voyage. Fruit in containers on the 2 palletized units were slower to cool down, and fruit temperatures remained 2 to 4°F above the optimum 50°F level. Relative humidity in the hold of the ship ranged between 93 and 96%.

In test shipment No. 2, the pulp temperatures of the fruit at time of loading ranged between 60° and 68°F. After 60 hr in the ship's hold, the temperature was reduced to 50°F, a temperature maintained during the remainder of the voyage.

Upon arrival in Japan, the fruit was inspected and fumigated by the Japanese Government before we made arrival-condition inspections of the experimental test containers and of the fruit that had received decay-control treatments. After 1 wk in storage at 50° to 55°F, the decay-control treatment containers were examined again.

Decay, bruising, and other types of product damage to the grapefruit in the test containers were small. Less than 1% decay was observed in the fruit for both shipments. However, the most decay was observed on grapefruit in the wax-dipped carton J.

The amount of deformed fruit found in all shipping containers, regardless of type, ranged from 33 to 60%. Although deformation is not technically considered product damage, the overall appearance of the fruit is seriously affected. The deformed fruit were more prevalent in the bottom layer of the cartons. In each of the 2 shipments, random inspection of the commercial fruit packed in the standard cartons had the same amount of deformation, except that the large fruit (size 27 and 32) shipped commercially with the test shipments had more seriously deformed surface areas than the smaller fruit (size 40 and 48).

Between the different types of shipping containers, differences in fruit shrinkage because of water loss were not significant. For the 2 shipments, fruit shrinkage averaged 3.6%.

In both test shipments, the appearance of the fruit that had received decay-control treatments was very good, with firm to fairly firm texture. Decay was 1% or less for all experimental treatments (2 through 9) on arrival and after 1 wk of holding at the warehouse. The control treatment (No. 1) in both tests had 5 and 6% decay, respectively, on arrival, and 7% decay after 1 wk. These control lots were exposed to

biphenyl vapors and would approximate the standard treatment allowed by the Japanese Government for imported citrus fruit.

The control lot for the decay-control treatments for both tests was held at Orlando during the simulated transit period without being exposed to biphenyl vapors. These lots were inspected after 28 days at 50°F, plus 1 wk at 70°F. Grapefruit in the control lots for both tests developed 3 and 4% decay, respectively, "on arrival." The amount of decay increased to 20 and 17% after the additional 1-wk holding period. No decay developed on grapefruit during the simulated transit period in the experimental treatments for both tests. However, during the additional holding period, 3, 11 and 8% decay developed on grapefruit that had received treatments 2, 3, and 4 in test No. 1, respectively, and from 2 to 6% decay for treatments 2, 3, 4, 5, 7, and 8, in test No. 2. Grapefruit that had received treatments 6 and 9 showed no decay after the additional 1-wk simulated transit holding period for both tests. Grapefruit in both the export and simulated tests developed some stem-end rind breakdown, but this breakdown was not increased by the fungicidal treatments. The decay which developed on grapefruit in both tests was primarily Phomopsis stem-end rot, with minor amounts of green-mold rot, sour rot, and anthracnose.

The amount of moisture absorbed by the container covers ranged from 8.2 to 13.0% with the waterproof nonwaxed covers (C and E), and the airflow cover (F) absorbing the least amount of moisture. Moisture absorbed by the container bodies ranged from 5.2 to 13.2% with the waterproof nonwaxed bodies (D and E), the airflow body (O), and the wax-impregnated curtain-coated body (K) showing slightly less moisture absorption than the other container bodies. However, shipping containers treated with moisture-resistant materials and/or fabricated from corrugated board heavier than the standard cartons showed about the same amount of carton damage, upon arrival, as did the standard cartons (A) (Table 3). Although a few of the cartons performed slightly better, it was apparent that cartons exposed to humidities ranging from 90 to 96% and under 300 lb of overhead weight for 44 and 45 days, respectively, for both tests reached about the same fatigue level (loss of carton strength). This fatigue is attributed to the amount of moisture that was absorbed into the liner facings and medium of the containers.

Meetings and discussions with Japanese customs, quarantine, and agricultural officials and receivers of the fruit helped to verify the advantages and disadvantages of the different types of shipping containers and the different decay control treatments studied. Every individual contacted was extremely interested in these grapefruit tests, and his cooperation was greatly appreciated. Following are recommendations as to the merit of exporting grapefruit in the different types of experimental shipping containers and the use of the different decay-control treatments.

TABLE 3.--Amount of physical damage to 15 types of shipping containers, two test shipments from Florida to Tokyo, Japan 1973[1]

Carton identification letter	Type of carton damage			
	Compression	Bottom sag	Side bulge	End bulge
	Inches			
Standard:				
A	3/8	1/2	1-1/4	3/4
Experimental:				
B	1/2	3/8	3/4	1/2
C	1/4	1/2	3/4	1/2
D	1/2	1/2	1-1/4	1
E	1/4	3/4	5/8	5/8
F	1/2	1-1/4	3/4	7/8
G[2]	3/4	3/4	1	1
H[2]	1/4	1-1/4	1	3/4
I	3/8	1/2	1	1
J	1/2	3/8	1	1
K	1/2	3/4	1	1
L	3/8	1/2	1	1
M	1/2	3/4	1	1
N	1/4	3/4	1	3/4
O	1/4	1-1/2	1-1/2	1

1/ Total number of 12 cartons of each type examined in two shipments.

2/ Film-sleeve wrap was removed from pallet units in hold of ship, and cartons were handled individually during unloading.

Continue: To evaluate cartons A, B, C, E, L, and N. Pack all of these cartons without bulge, or with slack. End-panel inserts, as used in carton L, should be used in A and E cartons to improve stacking strength. Cartons B and E showed minimum damage. Carton E also showed the least amount of moisture absorption. The Japanese stevedores and quarantine officials found that because of damage to the covers, carton C was difficult to handle. Therefore, the cover of carton C should be redesigned before further evaluations are made. The Japanese-made body of carton N appears prohibitively costly (estimated at 35 to 40 cents f.o.b. Japan), but the carton did show minimum container damage and warranted further study.

Discontinue: To evaluate cartons D, F, G, H, I, J, K, M, and O. Cartons D, I, and M showed no apparent advantage over the standard carton (A). The shrink-film sleeve wrap used to unitize the two pallets F and G hindered the cooling of the fruit. The airflow cover and airflow body (cartons F and O) showed no difference in cooling the fruit over the standard ventilation design, and also required special stacking for fumigation by the Japanese. Cartons J and K were difficult to handle and stack, and free water was found in the bottom of the cartons, as well as slightly more decay on the fruit. The Japanese also rejected cartons J and K because they were not recyclable.

It is strongly recommended that the Florida citrus industry test deep-cup trays fabricated from rigid pulpboard or plastic-type materials to prevent deformed fruit, especially for the larger 27- and 32-size fruit, in extended export shipments.

The results of the decay-control treatments indicate that better arrival conditions can be obtained if thiabendazole or a combination of sodium orthophenylphenate and thiabendazole could be used in lieu of, or in addition to, the biphenyl pads. At the present time, only biphenyl pads are approved by the Japanese Government for imported citrus. Sodium orthophenylphenate, 2-aminobutane, and thiabendazole are fully approved for use in the United States by the Environmental Protection Agency of the U.S. Government, and are currently being used by the citrus industry. Benomyl has also received experimental clearance and is currently being used on a trial basis. However, any fungicide used to reduce spoilage and to maintain the quality of citrus fruit shipped to Japan must have the approval of the Japanese Government.

No fungicide, however, can compensate for damage which may occur because of the rough handling of grapefruit from tree to consumer, overpacking them, or carton failure during transit.

Our Market Quality and Transportation Research Unit plans to conduct more extensive studies next season to determine the best methods of packing, handling, and transporting citrus in shipping containers to both domestic and overseas markets; and to continue studies to evaluate different fungicidal treatments and preparations for maintaining optimum conditions for citrus fruit during transit and on arrival.

We look forward to your cooperation and hope that we can continue this fine industry-wide relationship.

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Full telescope 3/	D	42-33-42	62-33-62	200	275	0	2
Full telescope 2/	E	42-33-62	62-33-62	250	275	0	2
Full telescope, airflow 4/	F	42-33-42	90-33-90	200	350	0	0
Full telescope, unitized	G	42-33-42	90-33-90	200	350	0	2
Full telescope, airflow, unitized 4/	H	42-33-42	90-33-90	200	350	0	0
Full telescope 4/ 5/	I	42-33-42	90-33-90	200	350	0	2
Full telescope 6/	J	42-33-42	69-33-69	200	275	0	2
Full telescope 4/ 7/	K	42-33-42	90-33-90	200	350	0	2
Full telescope 8/	L	42-33-42	90-33-90	200	350	0	2
Full telescope 9/	M	42-33-42	90-33-90	200	350	0	2
Full telescope	N	42-33-42	73-pm-73 10/	200	--	0	2
Full telescope, airflow	O	42-33-42	73-pm-73 10/	200	--	0	0

1/ Waterproof adhesives were used throughout in bodies of all shipping containers.
2/ Body and cover fabricated from waterproof, nonwaxed corrugated board. The 33-lb medium and the 62-lb liner of body and cover were wet strength.
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6/ Body was wax dipped.
7/ Liners and medium of body were wax impregnated; both liner facings of body were curtain coated.
8/ Inserts of 275 lb paper board weight were placed inside the carton body against each end panel and extended 1-1/2 in. around each corner of the cartons.
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All shipping containers tested (Table 1) measured inside 17 X 10-5/8 X 9-5/8 in., and were regular slotted cartons, except treatment C, a Bliss-style carton. Treatment C had a modified, full-telescope cover with no joint on the top surface or the bottom surface of the carton. All flaps and joints (Treatment C) were on the ends of both body and top halves.

A regular commercial packinghouse was used to pack a minimum of 50 cartons of each type of container for each test shipment -- all with size 40 Marsh Seedless grapefruit. Two biphenyl pads were used in each carton between each layer of fruit. The test shipping containers were loaded in the refrigerated holds of the ships in a tight stack, eight and nine high. The cartons (G and H) on the 2 palletized units were held together with an experimental shrink-film sleeve. Six cartons of each type of container were specially identified and placed in the bottom layer of the carton stacks to evaluate the unitizing and break-bulk handling methods used. Individual net weights of fruit packed in the shipping containers and the average moisture content of the cartons were recorded at the shipping point.

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5	Treatment #2 followed by Treatment #4	#93 Flavorseal wax
6	Thiabendazole, 3000 ppm	#93 Flavorseal wax with 4000 ppm Thiabendazole
7	Sodium orthophenylphenate, 2% Dowicide + 1% hexamine	#93 Flavorseal wax with 4000 ppm Thiabendazole
8	Benomyl, 1000 ppm	#93 Flavorseal wax
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ranged from 68° to 70°F. After 36 hr, the pulp temperatures of the fruit -- except fruit in the 2 palletized units (G and H) -- ranged from 50° to 52°F, a 18 to 20°F drop in temperature. There was no significant difference in the cooling rate of the grapefruit because of the container type or between containers with experimental airflow and standard ventilation. (The consistency here could be attributed to the efficient refrigeration system on this ship.) Temperatures were maintained (± 1°F) throughout the remainder of the voyage. Fruit in containers on the 2 palletized units were slower to cool down, and fruit temperatures remained 2 to 4°F above the optimum 50°F level. Relative humidity in the hold of the ship ranged between 93 and 96%.

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Decay, bruising, and other types of product damage to the grapefruit in the test containers were small. Less than 1% decay was observed in the fruit for both shipments. However, the most decay was observed on grapefruit in the wax-dipped carton J.

The amount of deformed fruit found in all shipping containers, regardless of type, ranged from 33 to 60%. Although deformation is not technically considered product damage, the overall appearance of the fruit is seriously affected. The deformed fruit were more prevalent in the bottom layer of the cartons. In each of the 2 shipments, random inspection of the commercial fruit packed in the standard cartons had the same amount of deformation, except that the large fruit (size 27 and 32) shipped commercially with the test shipments had more seriously deformed surface areas than the smaller fruit (size 40 and 48).

Between the different types of shipping containers, differences in fruit shrinkage because of water loss were not significant. For the 2 shipments, fruit shrinkage averaged 3.6%.

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biphenyl vapors and would approximate the standard treatment allowed by the Japanese Government for imported citrus fruit.

The control lot for the decay-control treatments for both tests was held at Orlando during the simulated transit period without being exposed to biphenyl vapors. These lots were inspected after 28 days at 50°F, plus 1 wk at 70°F. Grapefruit in the control lots for both tests developed 3 and 4% decay, respectively, "on arrival." The amount of decay increased to 20 and 17% after the additional 1-wk holding period. No decay developed on grapefruit during the simulated transit period in the experimental treatments for both tests. However, during the additional holding period, 3, 11 and 8% decay developed on grapefruit that had received treatments 2, 3, and 4 in test No. 1, respectively, and from 2 to 6% decay for treatments 2, 3, 4, 5, 7, and 8, in test No. 2. Grapefruit that had received treatments 6 and 9 showed no decay after the additional 1-wk simulated transit holding period for both tests. Grapefruit in both the export and simulated tests developed some stem-end rind breakdown, but this breakdown was not increased by the fungicidal treatments. The decay which developed on grapefruit in both tests was primarily Phomopsis stem-end rot, with minor amounts of green-mold rot, sour rot, and anthracnose.

The amount of moisture absorbed by the container covers ranged from 8.2 to 13.0% with the waterproof nonwaxed covers (C and E), and the airflow cover (F) absorbing the least amount of moisture. Moisture absorbed by the container bodies ranged from 5.2 to 13.2% with the waterproof nonwaxed bodies (D and E), the airflow body (O), and the wax-impregnated curtain-coated body (K) showing slightly less moisture absorption than the other container bodies. However, shipping containers treated with moisture-resistant materials and/or fabricated from corrugated board heavier than the standard cartons showed about the same amount of carton damage, upon arrival, as did the standard cartons (A) (Table 3). Although a few of the cartons performed slightly better, it was apparent that cartons exposed to humidities ranging from 90 to 96% and under 300 lb of overhead weight for 44 and 45 days, respectively, for both tests reached about the same fatigue level (loss of carton strength). This fatigue is attributed to the amount of moisture that was absorbed into the liner facings and medium of the containers.

Meetings and discussions with Japanese customs, quarantine, and agricultural officials and receivers of the fruit helped to verify the advantages and disadvantages of the different types of shipping containers and the different decay control treatments studied. Every individual contacted was extremely interested in these grapefruit tests, and his cooperation was greatly appreciated. Following are recommendations as to the merit of exporting grapefruit in the different types of experimental shipping containers and the use of the different decay-control treatments.

TABLE 3.--Amount of physical damage to 15 types of shipping containers, two test shipments from Florida to Tokyo, Japan 1973[1/]

Carton identification letter	Type of carton damage			
	Compression	Bottom sag	Side bulge	End bulge
	----------- Inches -------------			
Standard:				
A	3/8	1/2	1-1/4	3/4
Experimental:				
B	1/2	3/8	3/4	1/2
C	1/4	1/2	3/4	1/2
D	1/2	1/2	1-1/4	1
E	1/4	3/4	5/8	5/8
F	1/2	1-1/4	3/4	7/8
G[2/]	3/4	3/4	1	1
H[2/]	1/4	1-1/4	1	3/4
I	3/8	1/2	1	1
J	1/2	3/8	1	1
K	1/2	3/4	1	1
L	3/8	1/2	1	1
M	1/2	3/4	1	1
N	1/4	3/4	1	3/4
O	1/4	1-1/2	1-1/2	1

1/ Total number of 12 cartons of each type examined in two shipments.

2/ Film-sleeve wrap was removed from pallet units in hold of ship, and cartons were handled individually during unloading.

Continue: To evaluate cartons A, B, C, E, L, and N. Pack all of these cartons without bulge, or with slack. End-panel inserts, as used in carton L, should be used in A and E cartons to improve stacking strength. Cartons B and E showed minimum damage. Carton E also showed the least amount of moisture absorption. The Japanese stevedores and quarantine officials found that because of damage to the covers, carton C was difficult to handle. Therefore, the cover of carton C should be redesigned before further evaluations are made. The Japanese-made body of carton N appears prohibitively costly (estimated at 35 to 40 cents f.o.b. Japan), but the carton did show minimum container damage and warranted further study.

Discontinue: To evaluate cartons D, F, G, H, I, J, K, M, and O. Cartons D, I, and M showed no apparent advantage over the standard carton (A). The shrink-film sleeve wrap used to unitize the two pallets F and G hindered the cooling of the fruit. The airflow cover and airflow body (cartons F and O) showed no difference in cooling the fruit over the standard ventilation design, and also required special stacking for fumigation by the Japanese. Cartons J and K were difficult to handle and stack, and free water was found in the bottom of the cartons, as well as slightly more decay on the fruit. The Japanese also rejected cartons J and K because they were not recyclable.

It is strongly recommended that the Florida citrus industry test deep-cup trays fabricated from rigid pulpboard or plastic-type materials to prevent deformed fruit, especially for the larger 27- and 32-size fruit, in extended export shipments.

The results of the decay-control treatments indicate that better arrival conditions can be obtained if thiabendazole or a combination of sodium orthophenylphenate and thiabendazole could be used in lieu of, or in addition to, the biphenyl pads. At the present time, only biphenyl pads are approved by the Japanese Government for imported citrus. Sodium orthophenylphenate, 2-aminobutane, and thiabendazole are fully approved for use in the United States by the Environmental Protection Agency of the U.S. Government, and are currently being used by the citrus industry. Benomyl has also received experimental clearance and is currently being used on a trial basis. However, any fungicide used to reduce spoilage and to maintain the quality of citrus fruit shipped to Japan must have the approval of the Japanese Government.

No fungicide, however, can compensate for damage which may occur because of the rough handling of grapefruit from tree to consumer, overpacking them, or carton failure during transit.

Our Market Quality and Transportation Research Unit plans to conduct more extensive studies next season to determine the best methods of packing, handling, and transporting citrus in shipping containers to both domestic and overseas markets; and to continue studies to evaluate different fungicidal treatments and preparations for maintaining optimum conditions for citrus fruit during transit and on arrival.

We look forward to your cooperation and hope that we can continue this fine industry-wide relationship.

EXPORTING FLORIDA GRAPEFRUIT TO JAPAN-- AN EVALUATION OF NEW SHIPPING CONTAINERS AND DECAY-CONTROL TREATMENTS

Talk by Philip W. Hale, Agricultural Economist, and
John J. Smoot, Research Plant Pathologist,
U.S. Horticultural Research Laboratory, Orlando, Florida,
at the
1973 Annual Citrus Packinghouse Day
Agricultural Research and Education Center
Lake Alfred, Florida, September 5, 1973

It is a pleasure to participate in your Annual Citrus Packinghouse Day program. Basically, we all have the same objective in mind--to deliver fresh Florida grapefruit to domestic and overseas markets in the best possible condition. We are pleased to report that the information gained from two commercial shipping tests will be helpful in meeting this objective.

The results of evaluating new types of 4/5-bushel shipping containers and new decay-control treatments indicate that when better packaging techniques are used and improved fungicidal treatments are adopted, the appearance and condition of grapefruit on arrival at overseas markets will be enhanced.

This study is part of a broader research program by the U.S. Department of Agriculture and the citrus industry to find ways of reducing the cost of distributing and improving the arrival condition of agricultural food products at overseas markets. Trade names used in this report are solely to provide information. Mention of a trade name does not constitute an endorsement or warranty of the product by the U.S. Department of Agriculture.

This study evaluated 11 types of shipping containers (Table 1, identification letters A, B, C, D, E, I, J, K, L, M, and N) and 9 different decay-control treatments (Table 2) for exporting Florida Marsh Seedless grapefruit from Orlando, Florida, to Tokyo, Japan.

In addition to the 11 types of shipping containers, 2 other variations in containers were tested to compare the cooling rates of all containers with standard ventilated cartons (Table 1,A). Experimental airflow ventilation slots were cut into the bottom and top flaps of 2 of the carton types (Table 1, F and O). Also, 2 palletized units of cartons (Table 1, G and H) were included in the tests to observe handling methods and the effects of cooling rates of standard-ventilated and airflow-ventilated cartons when unitized on pallets. Thus, a total of 15 shipping containers were evaluated when 2 break-bulk shipments were conducted during March and April 1973, along with regular commercial shipments. The transit time for the 2 shipments from packinghouse (Florida) to destination (Japan) was 44 and 45 days, respectively.

TABLE 1.--Descriptions, specifications, and identification letters for the 15 types of shipping containers, 2 test shipments from Florida to Tokyo, Japan, 1973.

Type of carton 1/	Identification letter	Paperboard weight: Cover (lb/1,000 ft^2)	Paperboard weight: Body (lb/1,000 ft^2)	Bursting strength: Cover	Bursting strength: Body	Ventilation slots: End panel	Ventilation slots: Side panel
Standard: Fiberboard, full telescope	A	42-33-42	90-33-90	200	350	0	2
Experimental: Fiberboard							
Full telescope	B	42-33-42	69-33-69-33-69	200	500	0	2
Bliss-style 2/	C	42-33-62	42-33-62	250	250	2	3
Full telescope 3/	D	42-33-42	62-33-62	200	275	0	2
Full telescope 2/	E	42-33-62	62-33-62	250	275	0	2
Full telescope, airflow 4/	F	42-33-42	90-33-90	200	350	0	0
Full telescope, unitized	G	42-33-42	90-33-90	200	350	0	2
Full telescope, airflow, unitized 4/	H	42-33-42	90-33-90	200	350	0	0
Full telescope 4/ 5/	I	42-33-42	90-33-90	200	350	0	2
Full telescope 6/	J	42-33-42	69-33-69	200	275	0	2
Full telescope 4/ 7/	K	42-33-42	90-33-90	200	350	0	2
Full telescope 8/	L	42-33-42	90-33-90	200	350	0	2
Full telescope 9/	M	42-33-42	90-33-90	200	350	0	2
Full telescope	N	42-33-42	73-pm-73 10/	200	--	0	2
Full telescope, airflow	O	42-33-42	73-pm-73 10/	200	--	0	0

1/ Waterproof adhesives were used througnout in bodies of all shipping containers.
2/ Body and cover fabricated from waterproof, nonwaxed corrugated board. The 33-lb medium and the 62-lb liner of body and cover were wet strength.
3/ Body fabricated from waterproof, nonwaxed corrugated board. The 33-lb medium and the 62-lb liner of the body were wet strength.
4/ The 33-lb medium of the body was wet strength.
5/ The inside liner of body treated with Mikelman X-300 coating.
6/ Body was wax dipped.
7/ Liners and medium of body were wax impregnated; both liner facings of body were curtain coated.
8/ Inserts of 275 lb paper board weight were placed inside the carton body against each end panel and extended 1-1/2 in. around each corner of the cartons.
9/ Liners and medium of body were wet strength.
10/ Medium of body fabricated from 5-mil polypropylene.
-- Data not available.

All shipping containers tested (Table 1) measured inside 17 X 10-5/8 X 9-5/8 in., and were regular slotted cartons, except treatment C, a Bliss-style carton. Treatment C had a modified, full-telescope cover with no joint on the top surface or the bottom surface of the carton. All flaps and joints (Treatment C) were on the ends of both body and top halves.

A regular commercial packinghouse was used to pack a minimum of 50 cartons of each type of container for each test shipment -- all with size 40 Marsh Seedless grapefruit. Two biphenyl pads were used in each carton between each layer of fruit. The test shipping containers were loaded in the refrigerated holds of the ships in a tight stack, eight and nine high. The cartons (G and H) on the 2 palletized units were held together with an experimental shrink-film sleeve. Six cartons of each type of container were specially identified and placed in the bottom layer of the carton stacks to evaluate the unitizing and break-bulk handling methods used. Individual net weights of fruit packed in the shipping containers and the average moisture content of the cartons were recorded at the shipping point.

For the fungicide test shipments, four standard commercial-type cartons for each of 9 decay-control treatments (Table 2) were tested, using size 40 or 48 grapefruit. Biphenyl pads were placed between each layer of grapefruit inside the shipping containers in all treatments. The decay-control treatments were applied at the Orlando laboratory, after which the containers were handled, held in storage, and loaded with commercial fruit. Thus, fruit in these treatments were also exposed to biphenyl vapors. In addition, comparable sample lots of the decay-control treatments that were not exposed to biphenyl vapors were held at the Orlando laboratory for a simulated transit period.

In test shipment No. 1, thermocouple leads were inserted into a grapefruit packed in each type of carton at the fourth layer to record pulp temperatures during transit. A hygrothermograph was placed adjacent to the test shipping containers to monitor temperatures and relative humidity.

The second shipment was unaccompanied, and relative humidity was not recorded; however, the transit temperatures in the refrigerated hold of the ship were monitored by 4 recording instruments.

TEST RESULTS

In test shipment No. 1, the pulp temperatures of the fruit packed in all test containers after they were loaded into the hold of the ship

TABLE 2.--Descriptions of the decay-control treatments used on grapefruit, two test shipments from Florida to Tokyo, Japan, 1973.

Treatment No.	Fungicide application	Wax application
1	Control treatment, wash only	#93 Flavorseal wax
2	Sodium orthophenylphenate, 2% Dowicide + 1% hexamine	#93 Flavorseal wax
3	2-Aminobutane, 1%	#93 Flavorseal wax
4	Thiabendazole, 1200 ppm	#93 Flavorseal wax
5	Treatment #2 followed by Treatment #4	#93 Flavorseal wax
6	Thiabendazole, 3000 ppm	#93 Flavorseal wax with 4000 ppm Thiabendazole
7	Sodium orthophenylphenate, 2% Dowicide + 1% hexamine	#93 Flavorseal wax with 4000 ppm Thiabendazole
8	Benomyl, 1000 ppm	#93 Flavorseal wax
9	Wash only	#93 Flavorseal wax with 4000 ppm Benomyl

ranged from 68° to 70°F. After 36 hr, the pulp temperatures of the fruit -- except fruit in the 2 palletized units (G and H) -- ranged from 50° to 52°F, a 18 to 20°F drop in temperature. There was no significant difference in the cooling rate of the grapefruit because of the container type or between containers with experimental airflow and standard ventilation. (The consistency here could be attributed to the efficient refrigeration system on this ship.) Temperatures were maintained (± 1°F) throughout the remainder of the voyage. Fruit in containers on the 2 palletized units were slower to cool down, and fruit temperatures remained 2 to 4°F above the optimum 50°F level. Relative humidity in the hold of the ship ranged between 93 and 96%.

In test shipment No. 2, the pulp temperatures of the fruit at time of loading ranged between 60° and 68°F. After 60 hr in the ship's hold, the temperature was reduced to 50°F, a temperature maintained during the remainder of the voyage.

Upon arrival in Japan, the fruit was inspected and fumigated by the Japanese Government before we made arrival-condition inspections of the experimental test containers and of the fruit that had received decay-control treatments. After 1 wk in storage at 50° to 55°F, the decay-control treatment containers were examined again.

Decay, bruising, and other types of product damage to the grapefruit in the test containers were small. Less than 1% decay was observed in the fruit for both shipments. However, the most decay was observed on grapefruit in the wax-dipped carton J.

The amount of deformed fruit found in all shipping containers, regardless of type, ranged from 33 to 60%. Although deformation is not technically considered product damage, the overall appearance of the fruit is seriously affected. The deformed fruit were more prevalent in the bottom layer of the cartons. In each of the 2 shipments, random inspection of the commercial fruit packed in the standard cartons had the same amount of deformation, except that the large fruit (size 27 and 32) shipped commercially with the test shipments had more seriously deformed surface areas than the smaller fruit (size 40 and 48).

Between the different types of shipping containers, differences in fruit shrinkage because of water loss were not significant. For the 2 shipments, fruit shrinkage averaged 3.6%.

In both test shipments, the appearance of the fruit that had received decay-control treatments was very good, with firm to fairly firm texture. Decay was 1% or less for all experimental treatments (2 through 9) on arrival and after 1 wk of holding at the warehouse. The control treatment (No. 1) in both tests had 5 and 6% decay, respectively, on arrival, and 7% decay after 1 wk. These control lots were exposed to

biphenyl vapors and would approximate the standard treatment allowed by the Japanese Government for imported citrus fruit.

The control lot for the decay-control treatments for both tests was held at Orlando during the simulated transit period without being exposed to biphenyl vapors. These lots were inspected after 28 days at 50°F, plus 1 wk at 70°F. Grapefruit in the control lots for both tests developed 3 and 4% decay, respectively, "on arrival." The amount of decay increased to 20 and 17% after the additional 1-wk holding period. No decay developed on grapefruit during the simulated transit period in the experimental treatments for both tests. However, during the additional holding period, 3, 11 and 8% decay developed on grapefruit that had received treatments 2, 3, and 4 in test No. 1, respectively, and from 2 to 6% decay for treatments 2, 3, 4, 5, 7, and 8, in test No. 2. Grapefruit that had received treatments 6 and 9 showed no decay after the additional 1-wk simulated transit holding period for both tests. Grapefruit in both the export and simulated tests developed some stem-end rind breakdown, but this breakdown was not increased by the fungicidal treatments. The decay which developed on grapefruit in both tests was primarily Phomopsis stem-end rot, with minor amounts of green-mold rot, sour rot, and anthracnose.

The amount of moisture absorbed by the container covers ranged from 8.2 to 13.0% with the waterproof nonwaxed covers (C and E), and the airflow cover (F) absorbing the least amount of moisture. Moisture absorbed by the container bodies ranged from 5.2 to 13.2% with the waterproof nonwaxed bodies (D and E), the airflow body (O), and the wax-impregnated curtain-coated body (K) showing slightly less moisture absorption than the other container bodies. However, shipping containers treated with moisture-resistant materials and/or fabricated from corrugated board heavier than the standard cartons showed about the same amount of carton damage, upon arrival, as did the standard cartons (A) (Table 3). Although a few of the cartons performed slightly better, it was apparent that cartons exposed to humidities ranging from 90 to 96% and under 300 lb of overhead weight for 44 and 45 days, respectively, for both tests reached about the same fatigue level (loss of carton strength). This fatigue is attributed to the amount of moisture that was absorbed into the liner facings and medium of the containers.

Meetings and discussions with Japanese customs, quarantine, and agricultural officials and receivers of the fruit helped to verify the advantages and disadvantages of the different types of shipping containers and the different decay control treatments studied. Every individual contacted was extremely interested in these grapefruit tests, and his cooperation was greatly appreciated. Following are recommendations as to the merit of exporting grapefruit in the different types of experimental shipping containers and the use of the different decay-control treatments.

TABLE 3.--Amount of physical damage to 15 types of shipping containers, two test shipments from Florida to Tokyo, Japan 1973[1/]

Carton identification letter	Type of carton damage			
	Compression	Bottom sag	Side bulge	End bulge
	----------- Inches -------------			
Standard:				
A	3/8	1/2	1-1/4	3/4
Experimental:				
B	1/2	3/8	3/4	1/2
C	1/4	1/2	3/4	1/2
D	1/2	1/2	1-1/4	1
E	1/4	3/4	5/8	5/8
F	1/2	1-1/4	3/4	7/8
G[2/]	3/4	3/4	1	1
H[2/]	1/4	1-1/4	1	3/4
I	3/8	1/2	1	1
J	1/2	3/8	1	1
K	1/2	3/4	1	1
L	3/8	1/2	1	1
M	1/2	3/4	1	1
N	1/4	3/4	1	3/4
O	1/4	1-1/2	1-1/2	1

1/ Total number of 12 cartons of each type examined in two shipments.

2/ Film-sleeve wrap was removed from pallet units in hold of ship, and cartons were handled individually during unloading.

Continue: To evaluate cartons A, B, C, E, L, and N. Pack all of these cartons without bulge, or with slack. End-panel inserts, as used in carton L, should be used in A and E cartons to improve stacking strength. Cartons B and E showed minimum damage. Carton E also showed the least amount of moisture absorption. The Japanese stevedores and quarantine officials found that because of damage to the covers, carton C was difficult to handle. Therefore, the cover of carton C should be redesigned before further evaluations are made. The Japanese-made body of carton N appears prohibitively costly (estimated at 35 to 40 cents f.o.b. Japan), but the carton did show minimum container damage and warranted further study.

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It is strongly recommended that the Florida citrus industry test deep-cup trays fabricated from rigid pulpboard or plastic-type materials to prevent deformed fruit, especially for the larger 27- and 32-size fruit, in extended export shipments.

The results of the decay-control treatments indicate that better arrival conditions can be obtained if thiabendazole or a combination of sodium orthophenylphenate and thiabendazole could be used in lieu of, or in addition to, the biphenyl pads. At the present time, only biphenyl pads are approved by the Japanese Government for imported citrus. Sodium orthophenylphenate, 2-aminobutane, and thiabendazole are fully approved for use in the United States by the Environmental Protection Agency of the U.S. Government, and are currently being used by the citrus industry. Benomyl has also received experimental clearance and is currently being used on a trial basis. However, any fungicide used to reduce spoilage and to maintain the quality of citrus fruit shipped to Japan must have the approval of the Japanese Government.

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